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Associations Between Psychosocial Stress, Saturated Fat, Physical Activity, and Blood Glucose in Type 2 Diabetes

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Abstract

Background: Type 2 diabetes mellitus involves dysregulated glucose homeostasis due to impaired insulin production, secretion, or action. Psychosocial stress activates the HPA axis, elevates cortisol, and reduces insulin sensitivity; saturated fat intake may aggravate insulin resistance; physical activity enhances insulin-mediated glucose uptake and endothelial function. **Objective:** To examine associations between psychosocial stress, saturated fat intake, and physical activity with blood glucose among adults with T2DM attending Sawah Lebar Public Health Center, Bengkulu City, 2025. **Method:** Case–control study with purposive sampling (n=138). Data collected via validated stress scales, physical-activity questionnaires, and dietary assessments; univariate and bivariate analyses used chi-square tests. **Results:** No significant associations between psychosocial stress (p=0.518) or saturated fat intake (p=0.213) and blood glucose status. Physical activity was significantly associated with glycemic status (p=0.016), suggesting a protective effect. **Conclusion:** Despite plausible pathways linking saturated fat and stress to insulin resistance, only physical activity showed a significant association with glycemic control in this sample. Findings highlight physical activity as a modifiable behavioral target in T2DM management at the primary care level; larger, longitudinal studies with objective measures of diet, stress, and activity are warranted.

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Introduction

Type 2 diabetes mellitus (T2DM) is a multifactorial metabolic disease in which defects in insulin secretion, insulin action, or both progressively destabilize glucose homeostasis and precipitate vascular complications. Its expanding prevalence, driven by demographic ageing and urbanized sedentary living, imposes mounting clinical and economic burdens across health systems. Beyond inherited susceptibility, a triad of modifiable influences—psychosocial stress, dietary saturated fat, and habitual physical activity—has strong mechanistic plausibility for shaping glycemic status. Stress activates the hypothalamic–pituitary–adrenal axis, elevating cortisol and impairing insulin signaling. Saturated fat promotes lipotoxic and pro-inflammatory processes that degrade insulin action. In contrast, regular physical activity enhances insulin-mediated glucose uptake and vascular function. Taken together, these pathways suggest that an integrated assessment of stress exposure, saturated fat intake, and physical activity is crucial for effective diabetes management in contemporary settings (Ruze et al., 2023).

The societal costs of T2DM are particularly salient in low- and middle-income countries, where primary care must reconcile high caseloads with constrained resources. Direct medical spending and indirect productivity losses compound when early detection and sustained self management are inconsistent. Indonesia is emblematic: community health centers (puskesmas) shoulder the majority of routine diabetes care while balancing pharmacotherapy with lifestyle counseling and psychosocial support. In this context, clarifying the relative and combined contributions of psychosocial stress, saturated fat intake, and physical activity to glycemic status has pragmatic value, as it helps prioritize behavior-change targets that are feasible within primary care workflows and community programs (Hidaayah, 2015).

Notwithstanding the broad consensus that behavior and context matter, the evidence relating psychosocial stress, saturated fat consumption, physical activity, and glycemia in adults with type 2

diabetes mellitus (T2DM) remains inconsistent and at times contradictory. Many studies isolate single exposures, use heterogeneous measurement tools, or sample specialized clinical populations that do not accurately reflect real-world primary care. Consequently, clinicians and program planners lack locally relevant signals about which levers—stress reduction, modification of dietary fat quality and quantity, or increased daily activity—most reliably align with their patients' current glycemic status.

A general solution to this deficit is to conduct integrated, clinic-based assessments that concurrently quantify psychosocial, dietary, and physical activity exposures using validated instruments, while measuring glycemia with standardized point-of-care devices. Such designs can indicate which modifiable factors are most strongly associated with elevated blood glucose in routine care, enabling tailored counseling, more efficient triage to lifestyle interventions, and the development of community initiatives that concentrate effort where returns are most significant. The present study adopts this approach in a typical urban puskesmas—proximate to patients' daily lives, staff routines, and resource constraints—to yield findings that are immediately interpretable for local practice and policy.

The literature offers specific, testable propositions for each exposure domain. First, stress contributes to metabolic dysregulation through neuroendocrine pathways that attenuate insulin signaling and promote hepatic gluconeogenesis; observational work links higher stress scores with poorer glycemic indices, and some behavioral interventions report improved control when stress management is incorporated (Ruze et al., 2023). Second, saturated fat intake has been repeatedly implicated in insulin resistance via effects on membrane fluidity, ectopic lipid deposition, and inflammatory cascades; patterns rich in saturated fat correlate with adverse metabolic profiles, whereas dietary strategies that reduce saturated fat often coincide with improvements in insulin sensitivity (Tajadod et al., 2023; Uusitupa et al., 2019).

Third, physical activity exerts robust acute and chronic effects on insulin mediated glucose disposal through adaptations in skeletal muscle, endothelial function, and adipokine signaling. Even modest increases in physical activity can yield clinically meaningful glycemic improvements, while structured programs can amplify these benefits. Evidence from diverse settings indicates that counseling to reduce sedentary time and promote regular moderate-intensity activity can be effectively integrated into primary care, exhibiting favorable cost–benefit characteristics (Nurayati & Adriani, 2017; Uusitupa et al., 2019).
In Indonesia's primary care context, emerging reports have begun to map lifestyle correlates of diabetic control. In Bengkulu City, routine records and small observational studies suggest that patient level variation in activity and diet contributes to heterogeneous glycemic outcomes; however, systematic analyses that jointly evaluate psychosocial stress, saturated fat intake, and physical activity remain scarce. At Puskesmas Sawah Lebar, service data and prior descriptive work indicate variability in counseling uptake and self management practices, underscoring the need to empirically link these modifiable exposures with contemporaneous blood glucose measured during routine visits (Rahayuningsih et al., 2023). Thus, while biological plausibility and programmatic relevance converge, a clear local gap persists: few studies in Indonesian primary care have concurrently assessed stress, saturated fat intake, and physical activity using standardized instruments and related these factors to glycemic status in adults with established type 2 diabetes mellitus (T2DM).

Accordingly, this study aims to investigate the relationships between psychosocial stress, saturated fat intake, physical activity, and random blood glucose levels among adults with type 2 diabetes mellitus (T2DM) attending Puskesmas Sawah Lebar in Bengkulu. Its novelty lies in the integrated evaluation of three modifiable, routinely counselable exposures in a real-world primary-care cohort, using validated questionnaires and standardized point-of-care glucose measurements. Guided by prior evidence and mechanistic reasoning, we advance the following directional expectations: higher psychosocial stress will be associated with higher blood glucose; higher saturated fat intake will be associated with higher blood glucose; and higher physical activity will be related to lower blood glucose (Ruze et al., 2023; Tajadod et al., 2023; Nurayati & Adriani, 2017; Uusitupa et al., 2019). The scope is intentionally bounded to a single puskesmas to maximize contextual fidelity and implementation relevance. Focusing on adults with diagnosed T2DM in routine care, we employ validated instruments for stress and activity, a structured 24-hour recall for saturated fat intake, and point-of-care random capillary glucose as the outcome. By grounding the inquiry in the operational realities of Indonesian primary care while leveraging established measurement tools, the study aims to generate actionable evidence to inform clinic counseling, community health promotion, and the prioritization of lifestyle support services for people living with T2DM in Bengkulu and comparable settings (Hidaayah, 2015; Rahayuningsih et al., 2023; Uusitupa et al., 2019).

Methods

This study applies a quantitative approach with observational analysis by combining case-control design. This design was chosen to test the comparison between the categories, namely the category that

experienced cases and the control category, focusing on the effect of psychosocial stress, saturated fat consumption, and physical activity level on blood glucose levels (Asyumdah et al., 2020). The purpose of this method is to evaluate the differences associated between individuals with stable and unstable blood glucose levels, as well as identify the factors that contribute the most to the condition (Syaripudin et al., 2023). The research was carried out over a three-month period, from February to April 2025, at the Sawah Lebar Health Center, Bengkulu City, which according to a report by the local Health Office has the highest number of cases of Type 2 Diabetes Mellitus (Paturusi et al., 2024). This research has obtained an ethics license number No. KEPK. BKL209/04/2025.

The study population included all DMT2 patients registered at the Sawah Lebar Health Center. Of the 138 samples collected, 97 patients were classified as a case group (at irregular blood glucose levels, specifically 200 mg/dL) and 41 people were classified as a control group for normal blood sugar levels (9Chudray, et al., 2019). The instruments and tools used include: (1) a DASS-21 questionnaire to measure psychosocial stress levels, (2) a 3x24-hour food recall form filled out with the help of researchers, (3) a PAL questionnaire to measure physical activity levels, and (4) a glucometer device (Accu-Chek) to measure blood glucose levels at a time.

Once the data is collected, the data entry stage is done manually into the SPSS software edition 25.0. To describe the characteristics and distribution of respondents, univariate analysis was carried out for each variable (Rahyuningsih, et al., 2023). For the analysis of two variables, the chi-square test was applied to assess the relationship between the analyzed variables consisting of less p-values based on a value of 0.05, it was seen that there was a statistically significant relationship between the research variables. To ensure the accuracy of the analysis regarding saturated fat intake, the information from the food reminder is converted into a measure of weight in grams by calculating total oil consumption, which is then summed up and compared to the saturated fat requirement based on the 2019 Dietary Reference Intake (Safitri., 2024).

Results

A total of 138 adults with documented type 2 diabetes mellitus (T2DM) receiving routine care at Puskesmas Sawah Lebar were enrolled between February and April 2025. All participants provided complete data on the three primary exposures—psychosocial stress, saturated fat intake, and physical activity—and on the outcome, random blood glucose (RBG), resulting in a complete analytic sample with no exclusions due to missing data. Participants were predominantly older adults (53.6% aged 60–72 years, 39.1% aged 45–59 years, and 7.2% aged 35–44 years) and were primarily women (69.6%).

Distributions of the primary exposures showed substantial heterogeneity. On the DASS 21 stress subscale, 46.4% of participants were classified as usual, 23.9% as moderate, and 29.7% as severe. Based on three non consecutive 24 hour dietary recalls, saturated fat intake was categorized as low (27.5%), adequate (44.2%), or high (28.3%). Physical activity level (PAL) skewed toward the moderate category (71.1%), with 26.8% reporting light activity and 1.4% reporting vigorous activity. At the point of care, 29.7% of participants had RBG within the clinic's standard range and 70.3% had high RBG, reflecting a substantial burden of suboptimal glycemic control in this primary care population.

Table 1. Sample characteristics and primary variables (N=138)

Variable	Category	n	%
Age (years)	35–44	10	7.2
	45–59	54	39.1
	60–72	74	53.6
Sex	Female	96	69.6
	Male	42	30.4
Psychosocial stress (DASS-21)	Normal	64	46.4
	Moderate	33	23.9
	Severe	41	29.7
Saturated fat intake	Low	38	27.5
	Adequate	61	44.2
	High	39	28.3
Physical activity level	Light	37	26.8
	Moderate	99	71.1
	Vigorous	2	1.4

Variable	Category	n	%
Blood glucose status	Normal	41	29.7
	High	97	70.3

Analyses assessed associations between each exposure and RBG status. For psychosocial stress, the proportion with high RBG rose numerically across categories—65.6% (normal), 72.7% (moderate), and 75.6% (severe)—but the overall chi-square test was not statistically significant (p = 0.518), indicating that the observed differences were compatible with chance given the sample size. For saturated fat intake, the prevalence of high RBG was 60.5% in the low-intake group, 77.0% in the adequate-intake group, and 69.2% in the high-intake group; again, the association was not statistically significant (p = 0.213), and the non-monotonic pattern suggests heterogeneity in diet profiles and potential unmeasured co-factors. In contrast, RBG status differed significantly by physical activity level (p = 0.016): 59.5% of those reporting light activity had high RBG, compared with 75.8% in the moderate group; both participants in the vigorous group had normal RBG. Given the minimal number classified as vigorous (n = 2), those category-specific estimates should be interpreted descriptively; the omnibus result is primarily driven by differences between the light and moderate groups.

Table 2. Associations of primary exposures with random blood glucose status (N=138)

Variable	Category	Normal RBG n (%)	High RBG n (%)	Total n (%)	p-value
Psychosocial stress (DASS-21)	Normal	22 (34.4)	42 (65.6)	64 (46.4)	
	Moderate	9 (27.3)	24 (72.7)	33 (23.9)	0.518
	Severe	10 (24.4)	31 (75.6)	41 (29.7)	
Saturated fat intake	Low	15 (39.5)	23 (60.5)	38 (27.5)	
	Adequate	14 (23.0)	47 (77.0)	61 (44.2)	0.213
	High	12 (30.8)	27 (69.2)	39 (28.3)	
Physical activity level	Light	15 (40.5)	22 (59.5)	37 (26.8)	
	Moderate	24 (24.2)	75 (75.8)	99 (71.1)	0.016
	Vigorous	2 (100.0)	0 (0.0)	2 (1.4)	

Discussion

This clinic based evaluation of 138 adults with type 2 diabetes mellitus (T2DM) in Bengkulu's primary care shows a clear, statistically significant relationship between physical activity level (PAL) and contemporaneous random blood glucose (RBG), while analogous associations for psychosocial stress (DASS 21) and saturated fat intake, derived from three non consecutive 24 hour recalls, were not detected. Roughly two thirds of participants presented with elevated RBG at the point of care, underscoring a substantial burden of suboptimal glycemic control in this routine service context. The distribution of RBG across PAL categories differed meaningfully (omnibus p = 0.016): light activity participants exhibited a lower prevalence of high RBG than those reporting moderate activity, and the very small vigorous stratum (n = 2) showed exclusively normal RBG. By contrast, gradients across stress severity (p = 0.518) and saturated fat categories (p = 0.213) did not meet conventional significance thresholds, although point estimates were directionally compatible with higher proportions of high RBG at higher stress and a non monotonic pattern across fat intake categories.

The PAL–RBG association is congruent with robust mechanistic and clinical evidence that habitual movement improves insulin mediated glucose disposal through both acute (insulin independent GLUT 4 translocation) and chronic (increased skeletal muscle oxidative capacity) pathways, while also enhancing endothelial function and modulating adipokine and inflammatory signaling (Nurayati & Adriani, 2017; Uusitupa et al., 2019). That the moderate group carried a higher proportion of elevated RBG than the light group merits careful reading. Several explanations are plausible and not mutually exclusive: reverse causation (individuals struggling with glycemia may be counseled to undertake more activity and thus report "moderate"), exposure misclassification intrinsic to self reported PAL (intensity over or under statement), and misalignment in timing between recalled activity and the point of care glucose measurement. The tiny vigorous cell (n = 2) precludes stable category specific estimation at the upper end of activity. Nevertheless, the omnibus signal affirms physical activity as a salient behavioral correlate of glycemic status in this primary care population, consonant with guidance prioritizing movement focused counseling (Nurayati & Adriani, 2017; Uusitupa et al., 2019).

The null result for psychosocial stress should not be construed as evidence against a stress–glycemia pathway; rather, it likely reflects measurement and design constraints that attenuate detectable

effects in routine care. The DASS-21 stress subscale captures perceived stress over the prior week—a relatively short window that may fail to index chronic allostatic load or physiological reactivity, more proximally implicated in insulin resistance via hypothalamic–pituitary–adrenal activation and cortisol dynamics (Ruze et al., 2023). Unmeasured or imperfectly measured buffers—such as coping skills, social support, sleep quality, or medication adherence—could confound the associations between stress reports and glycemia. Power limitations within category splits also reduce sensitivity to modest effects. In aggregate, these considerations suggest that the present non significant gradient ($p = 0.518$) is compatible with actual effects that are either minor, transient, or insufficiently aligned with the instrument's recall horizon, echoing literature that calls for multimodal stress assessment, including biomarkers such as hair or salivary cortisol and repeated measures across time (Ruze et al., 2023).

Similarly, the absence of a statistically reliable association between saturated fat intake and RBG ($p = 0.213$), alongside a higher prevalence of elevated RBG in the "adequate" than the "low" or "high" categories, invites a contextual reading. Three non-consecutive recalls improve the estimation of usual intake compared with a single day; yet, day-to-day variability, memory limits, and social desirability can still bias reports. Categorization further compresses variance and may obscure dose–response relations. At the physiological level, saturated fat exerts effects within whole-diet matrices; substitution patterns (e.g., refined carbohydrates replacing fat) and energy balance can blunt the expected cross-sectional links with glycemia at a single time point. Pharmacotherapy, disease duration, and adiposity trajectories plausibly moderate diet–glycemia expressions. These factors, coupled with clinic based heterogeneity, help reconcile our null findings with a substantial body of work that implicates saturated fat in insulin resistance through membrane fluidity, ectopic lipid deposition, and pro inflammatory cascades, and that documents metabolic improvements when saturated fat is reduced within comprehensive diet quality upgrades (Tajadod et al., 2023; Uusitupa et al., 2019). The present data, therefore, support a cautious interpretation: under the current measurement scheme and sample structure, any association may be modest or context dependent rather than absent.

Considered together, the results integrate coherently with a literature that consistently elevates physical activity as a cornerstone of glycemic management while reporting mixed findings for psychosocial stress and saturated fat in community and primary care samples—variability often traceable to differences in instruments, exposure windows, and outcome definitions (Nurayati & Adriani, 2017; Uusitupa et al., 2019; Ruze et al., 2023; Tajadod et al., 2023). Local features in Bengkulu—including typical dietary patterns, occupational and transport related activity, and the texture of family and community support—likely condition observed associations. By embedding measurement within ordinary puskesmas operations, the study contributes setting specific evidence and illustrates how behavior–glycemia linkages hinge on the alignment of constructs, timing, and analytic granularity.

Practice implications flow directly from these observations. First, routine consultations should consistently integrate brief, structured movement counseling that emphasizes incremental increases in ambulatory activity, deliberate breaks from sedentary time, and practical home based routines suitable for older adults. Light-touch, low-cost behavior support (e.g., peer walking groups or WhatsApp-mediated accountability) is congruent with resource realities and may enhance adherence (Hidaayah, 2015). Second, counseling on stress and dietary fat should be retained but refined: opportunistic stress screening can be paired with simple coping strategies and referral pathways, while nutrition dialogue should pivot from nutrient myopia toward whole diet quality—fat quality, fiber, and minimally processed foods—given the measurement challenges and substitution dynamics surrounding saturated fat in isolation (Tajadod et al., 2023; Uusitupa et al., 2019). Interventions should be iterative, culturally attuned, and family aware to fit daily routines and caregiving structures.

These recommendations are bolstered by methodological strengths that enhance real-world credibility, including standardized instruments for stress and activity, multi-day dietary recalls to buffer day-level noise, and point-of-care glucose testing supported by daily device verification. At the same time, limitations circumscribe inference. The cross-sectional, case–control architecture precludes causal claims; self-report for stress, diet, and activity invites recall and desirability biases; the vigorous-activity category was too small for stable estimands; and single-center sampling narrows generalizability beyond similar urban puskesmas. Residual confounding by medication adherence, sleep, comorbid burden, or socioeconomic constraints is plausible, and categorization of continuous exposures may have diluted the signal.

Future research in Indonesian primary care should therefore adopt longitudinal and interventional designs that combine device based activity monitoring with repeated dietary assessments and objective stress biomarkers to reduce misclassification and clarify temporal ordering (Ruze et al., 2023; Uusitupa et al., 2019). Multi-center recruitment across puskesmas would increase precision and external validity, while a mixed-methods inquiry could elucidate how patients interpret, adopt, and sustain recommended

behaviors. Pragmatic trials of digitally supported, couple- or family-inclusive activity promotion—integrated with micro-interventions for nutrition and stress management—would test scalable models that fit routine workflows and community realities (Hidaayah, 2015; Rahayuningsih et al., 2023).

In conclusion, within a real-world primary-care cohort of adults with T2DM, physical activity level emerged as a significant correlate of contemporaneous glycemic status, whereas psychosocial stress and saturated fat intake did not, under the instruments and categorization used. The pattern reinforces the centrality of movement focused counseling in puskesmas while motivating more granular, temporally sensitive measurement of stress and diet. Embedding such refined assessment in routine services can help Indonesian primary care identify the most actionable levers for glycemic improvement in Bengkulu and comparable settings (Nurayati & Adriani, 2017; Tajadod et al., 2023; Uusitupa et al., 2019; Ruze et al., 2023; Hidaayah, 2015; Rahayuningsih et al., 2023).

Conclusion

This study indicates that physical activity level is the only examined, modifiable exposure that consistently aligns with contemporaneous random blood glucose, whereas psychosocial stress and saturated fat intake show no clear associations under the applied instruments and temporal windows. These findings elevate movement-centered counseling as an immediate and feasible priority for puskesmas, while interpreting the null patterns for stress and diet as products of measurement horizon, contextual heterogeneity, and analytic granularity rather than a definitive absence of effect. The work contributes setting-specific evidence by integrating behavioral, dietary, and psychosocial domains within real-world workflows, thereby clarifying which intervention targets are currently most actionable for glycemic management in this context.

Suggestion

The study offers a number of recommendations for future research, particularly on this study. Future studies are recommended to consider additional variables, such as length of illness, medication use, and adherence to therapy, to obtain more comprehensive results. Puskesmas are expected to routinely hold health education on the importance of physical activity, stress management, and a healthy diet by involving competent medical personnel. In addition, it is hoped that DMT2 sufferers will be more active in maintaining their health through the implementation of a healthy lifestyle and a balanced diet.

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